Cell and molecular biology

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Topics included in cell and general physiology

- Functional organization of human body.
- Homeostasis.
- Control system in the body.
- Cell membrane and its function.
- Intracellular connections
- Cell organelles.
- Transport through cell membrane.
- Membrane transport including active transport, passive transport, simple and facilitated diffusion.
- Types of particles in solution.
- Importance of selective permeable membrane, osmosis and osmotic pressure, surface tension, viscosity also in relation to body fluids.
- Abnormalities of cell and its organelles(opoptosis,mutation,cancer and aging.)

- **Wonders in the world of cell never ceases**

Cell membrane

- Gate way to the cell
- It separates living from non living surrounding.
- Controls traffic in and out of the cell.
- Maintain the cell potential,cell movement, cell recognition.
- Movements of substances across the membrane-channels,pumps ,transporters.
- Provide anchoring sites for filaments of cytoskeleton.
- Provides a binding sites for enzymes and receptors for chemicals and drugs.
- Interlocking surface bind cell together(junctions).
- Thin about 7 nm.
- At high magnification it can be seen to have three layers described as Trilaminar appearance.

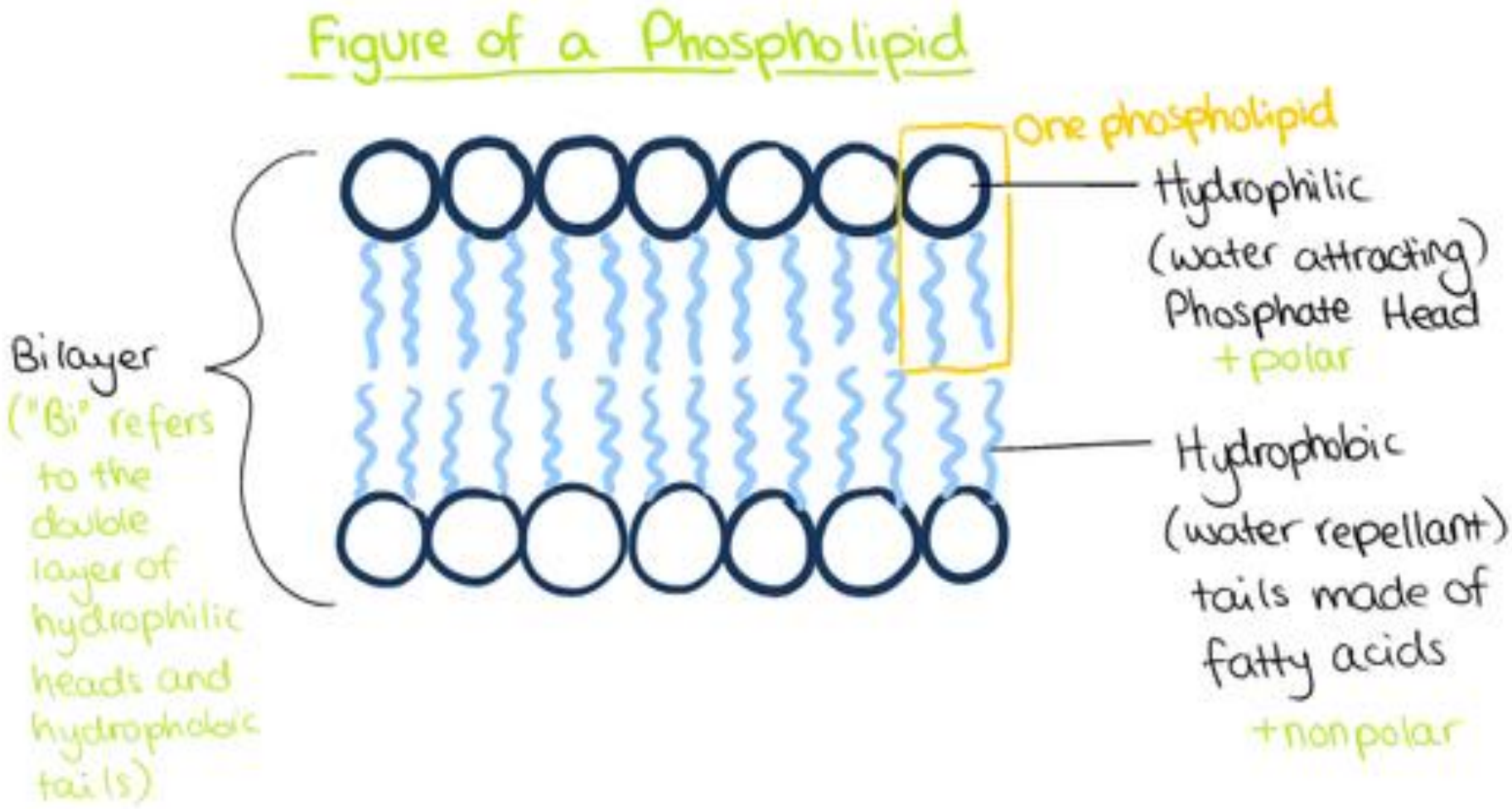
Cell membrane

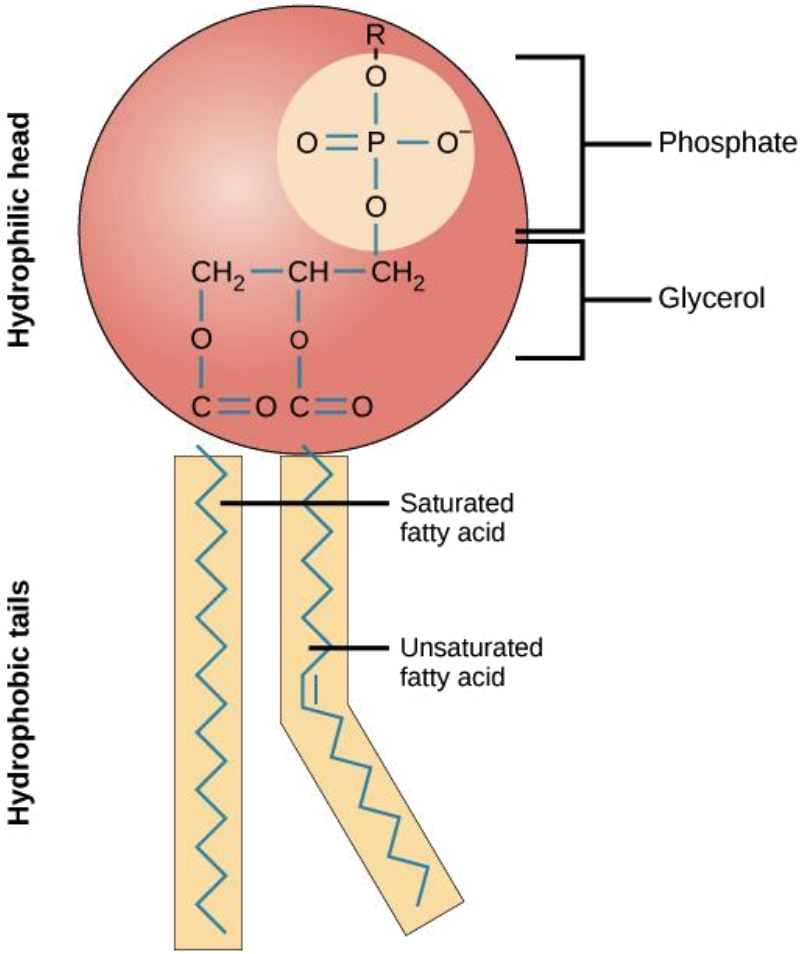
- A dynamic structure,semipermeable,made up of lipids and proteins.
- Allows a selective permeability.
- Major macromolecules in membrane are lipids, proteins and some carbohydrates
- Basic structure made up a lipid bi layer in which proteins are scattered.
- The function of membrane protein is transporter,enzyme action,cell surface receptor,cell surface identity marker,cell surface adhesions,attachment to cyto skeleton.
- are impermeable to fat soluble substances
- **in some tissues permit permits transport of glucose at a greater rate in the presence of insulin**
- are not changed through out the life

Lipids of cell membrane.

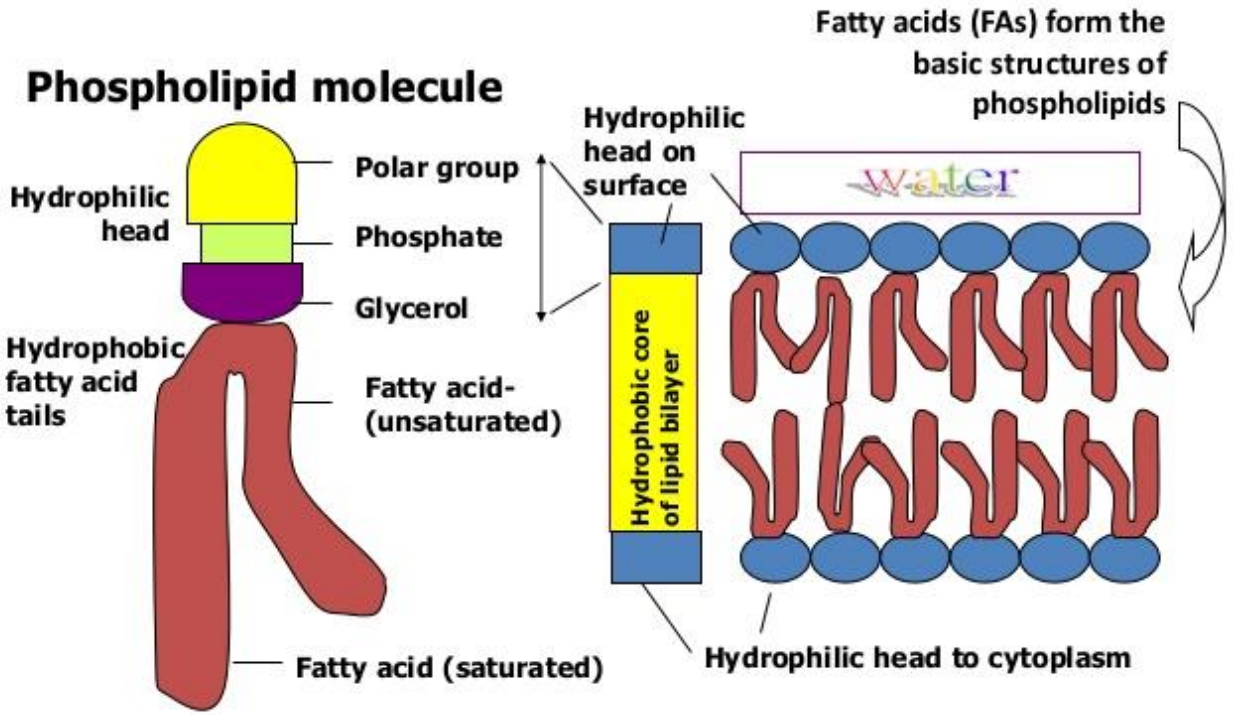
- Main lipid are phospholipids(most common) and cholesterol.
- Structure of phosphlipids molecules is such that head end has phosphate part and soluble in water i,e polar hydrophilic.
- Tail end made up of fatty acids and is water insoluble water insoluble i,e non polar,hydrophobic.
- Hydrophilic ends face interior and exterior of membrane with aqueous environment. Hydrophobic end meet in center of membrane.

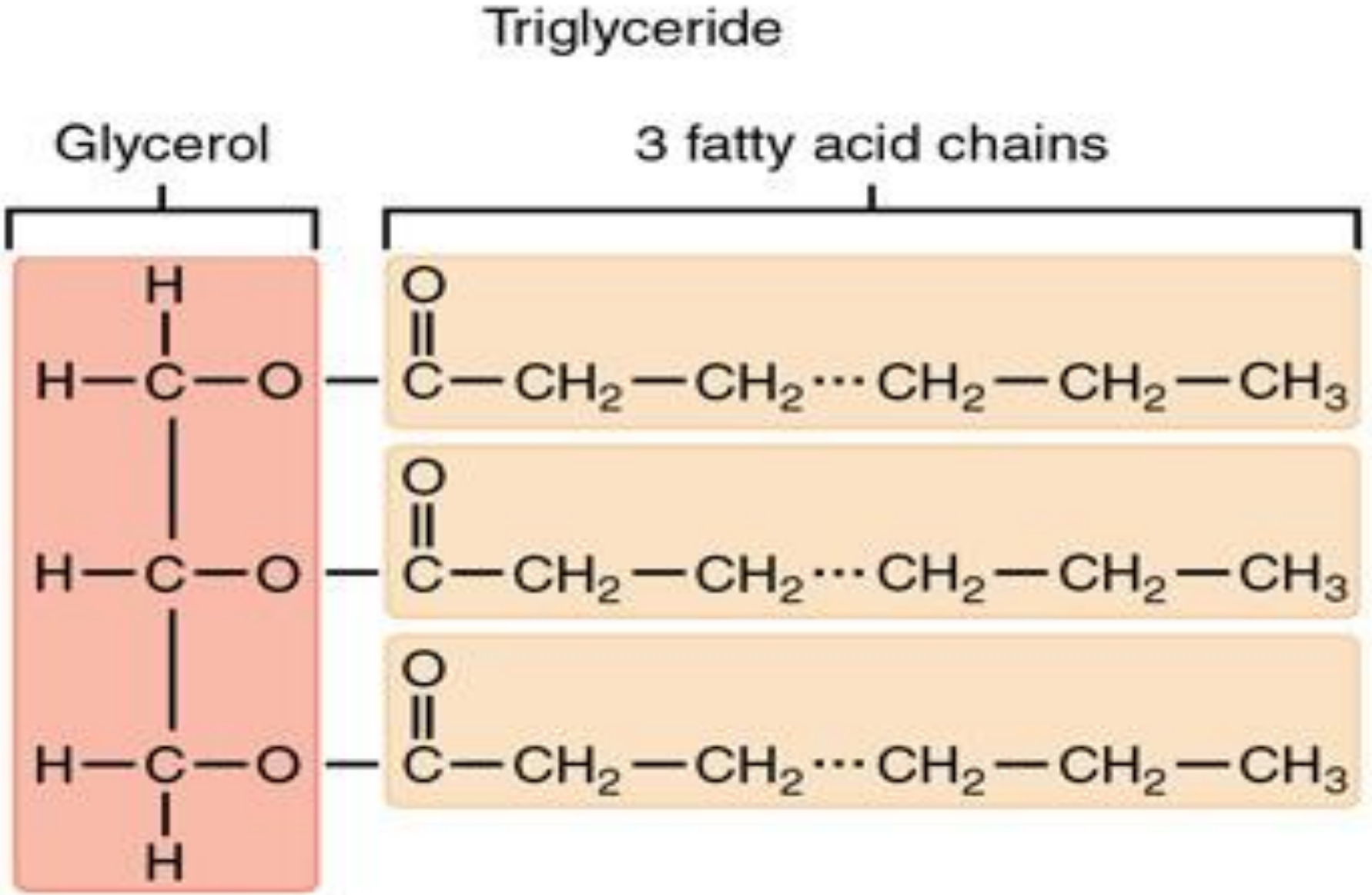
Cell membrane.




Hydrophilic head
Hydrophobic tails
R
O
O = P — O⁻
O
CH2 — CH — CH2
O O
C = O C = O
Phosphate
Glycerol
Saturated fatty acid
Unsaturated fatty acid

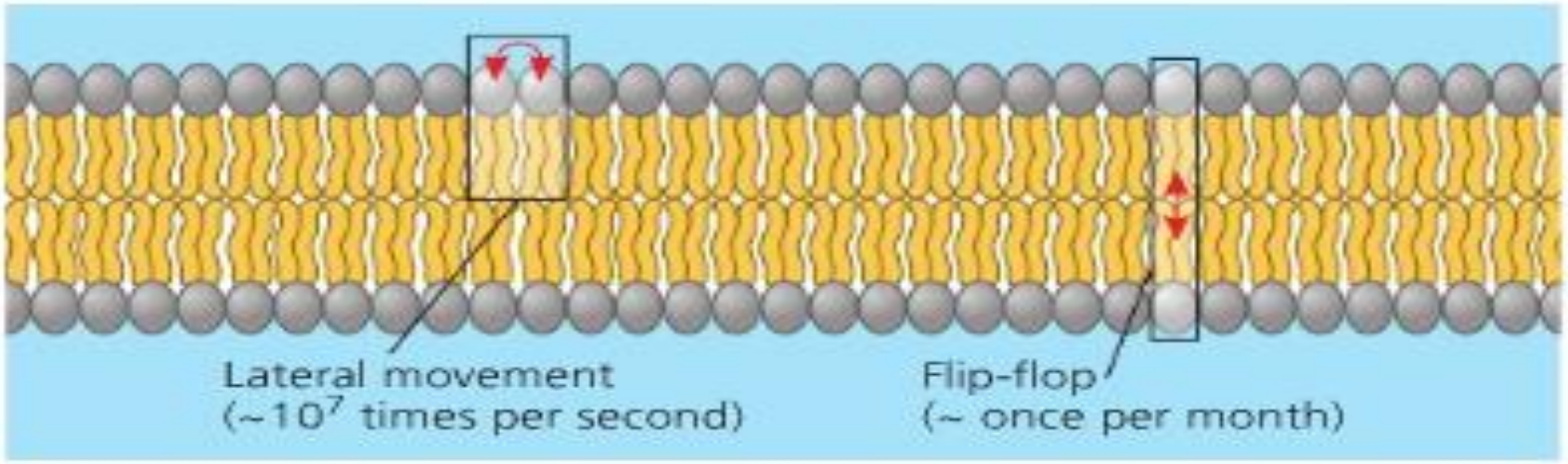
1.2.1 Simplified structure of lipid bilayer and phospholipids



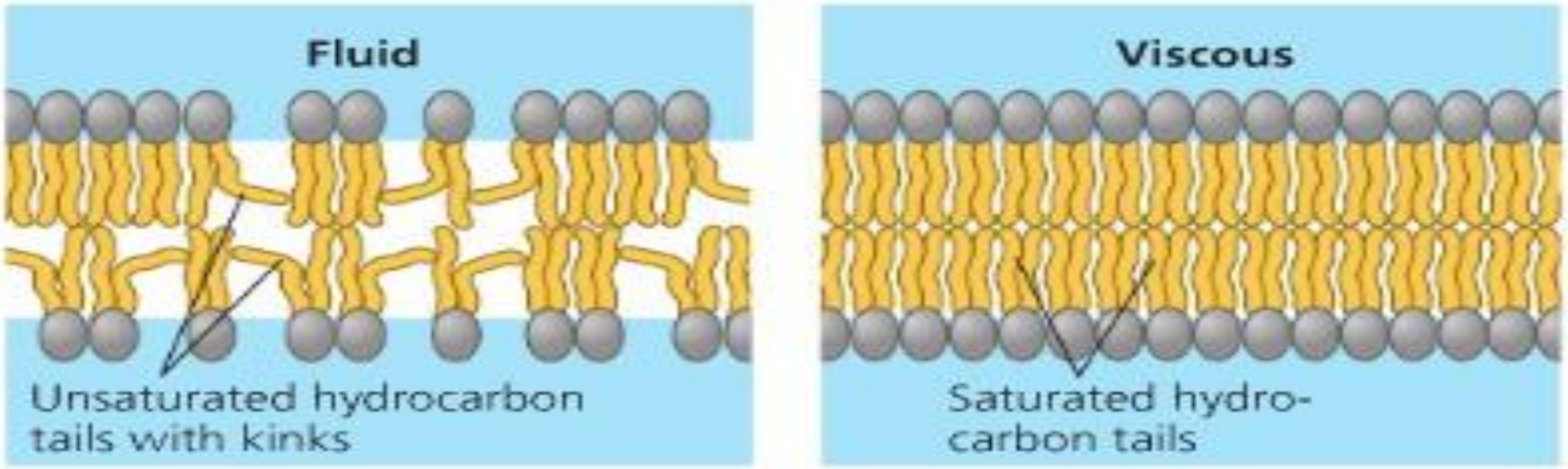

Triglyceride
Glycerol
3 fatty acid chains
H
H—C—O
H—C—O
H—C—O
H
O
C—CH2—CH2···CH2—CH2—CH3
O
C—CH2—CH2···CH2—CH2—CH3
O
C—CH2—CH2···CH2—CH2—CH3

Movements in cell membrane.

- Phospholipids are not attached to any structure and each molecules is free to move.
- This allows random **lateral movement** of both lipids and proteins of the cell.(Lateral movement of its component indicates the fluidity of the membrane).
- Fluidity enables the membrane to perform endocytosis and exocytosis.
- Lipid bilayer is **highly flexible fluid** in nature. This allows considerable alterations in cell shape.
- However the components do not freely move from inner to outer layer or outer to inner layer(flip flop movement is restricted).During Apoptosis (programmed cell death)flip flop movement occurs.



(a) Movement of phospholipids. Lipids move laterally in a membrane, but flip-flopping across the membrane is quite rare.



(b) Membrane fluidity. Unsaturated hydrocarbon tails of phospholipids have kinks that keep the molecules from packing together, enhancing membrane fluidity.

Decreases the fluidity of the membrane due to close packing of hydrocarbon chain.

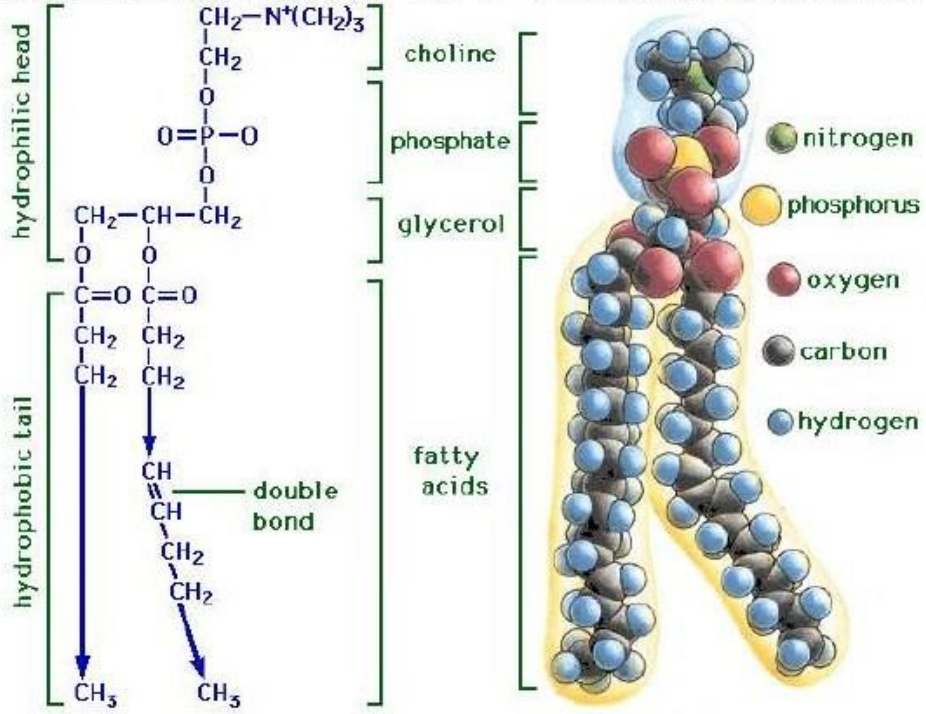
- The nature of the fatty acids also affects the fluidity of the membrane, the more unsaturated cis fatty acids increases the fluidity.
- the fluidity of the membrane is maintained by the length of hydro carbon chain,degree of unsaturation and nature of polar head group.
- Trans fatty acid decrease the fluidity of the membrane due to close packing of hydrocarbon chain.
- Increase fluidity of membrane favors the binding of insulin to its receptors,a transmembrane protein.

- Membrane is permeable to lipid soluble substances like O2,CO2,alcohal etc while water soluble substances cross it via channels ,pumps, or with the help of carrier proteins.

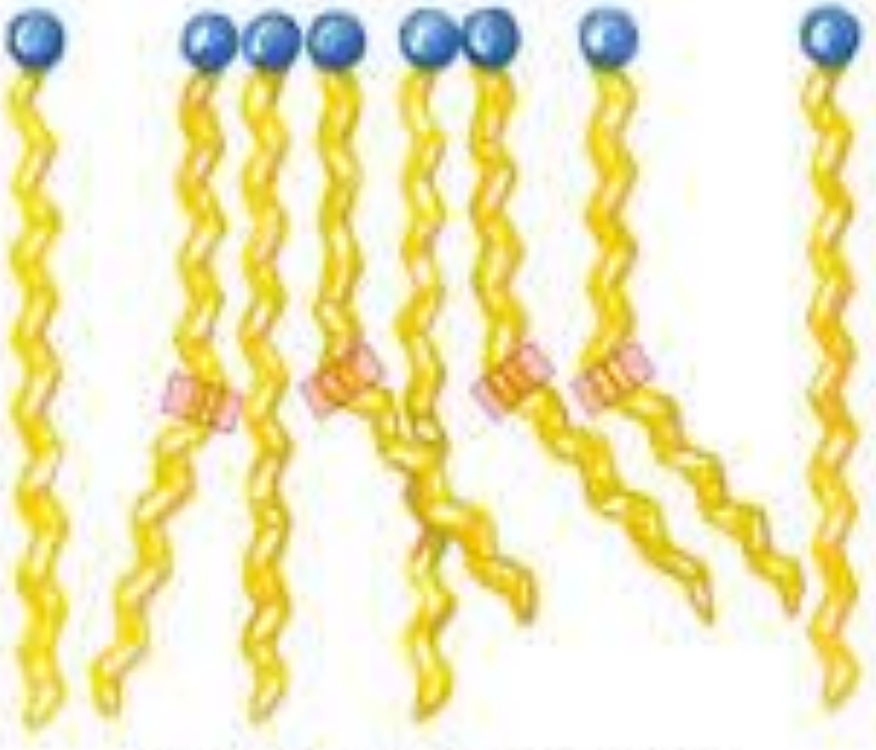
BILIPID LAYER BEHAVIOUR

- At a given temp ,Short tail lipid --- more fluidity
- Longer tailed lipid have more area over which to interact--- increasing the strength of this interaction ----decreasing lipid mobility.
- Unsaturated double bond can produce a kink in the alkane chain --- disrupting the lipid packing--- this disruption creates extra free space within the bilayer that allows additional flexibility in the adjacent chain.

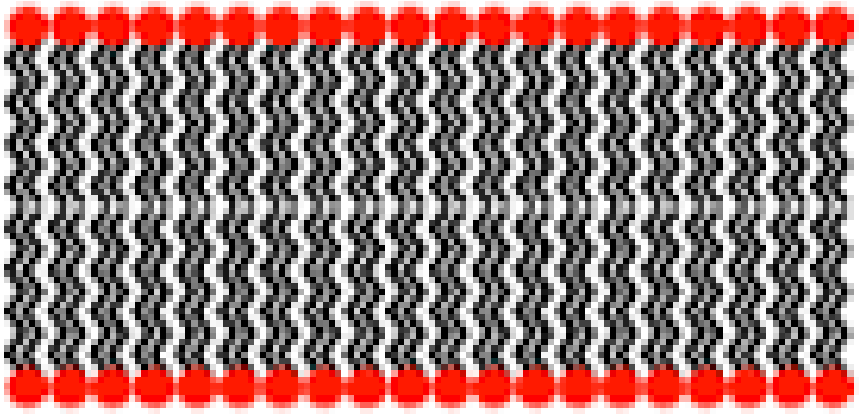
Structure of a Phospholipid



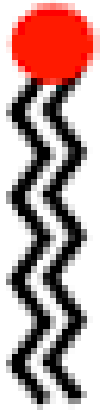
Saturated
fatty acids



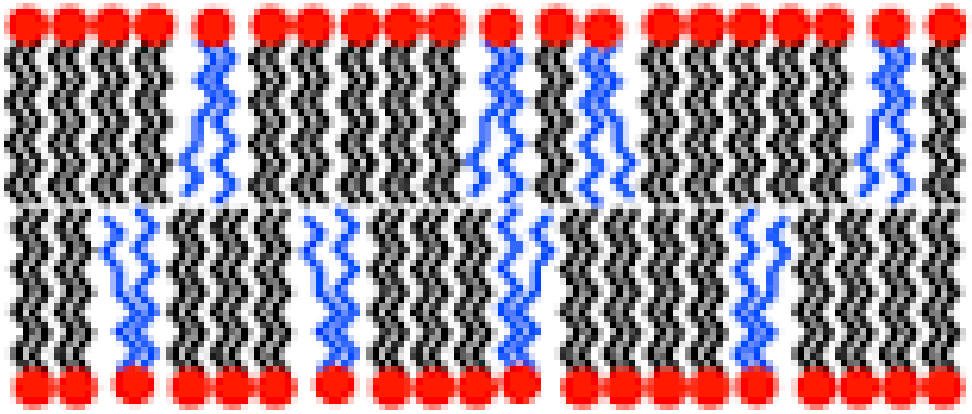
Mixture of saturated and
unsaturated fatty acids



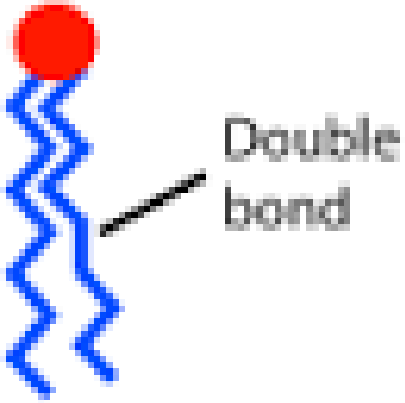
Saturated lipids only



Saturated



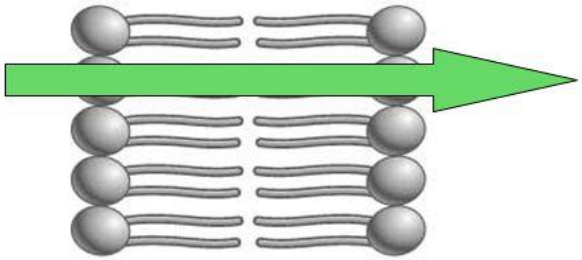
Mixed saturated and unsaturated



Monounsaturated

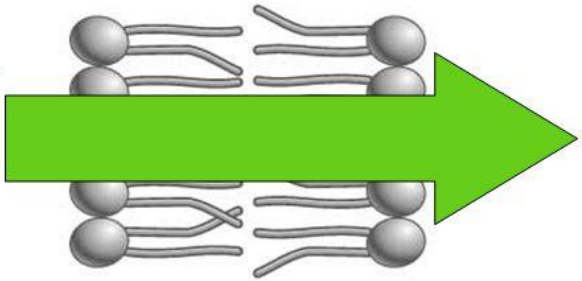
Kinks change the fluidity and permeability of membranes.

Lipid bilayer with no unsaturated fatty acids



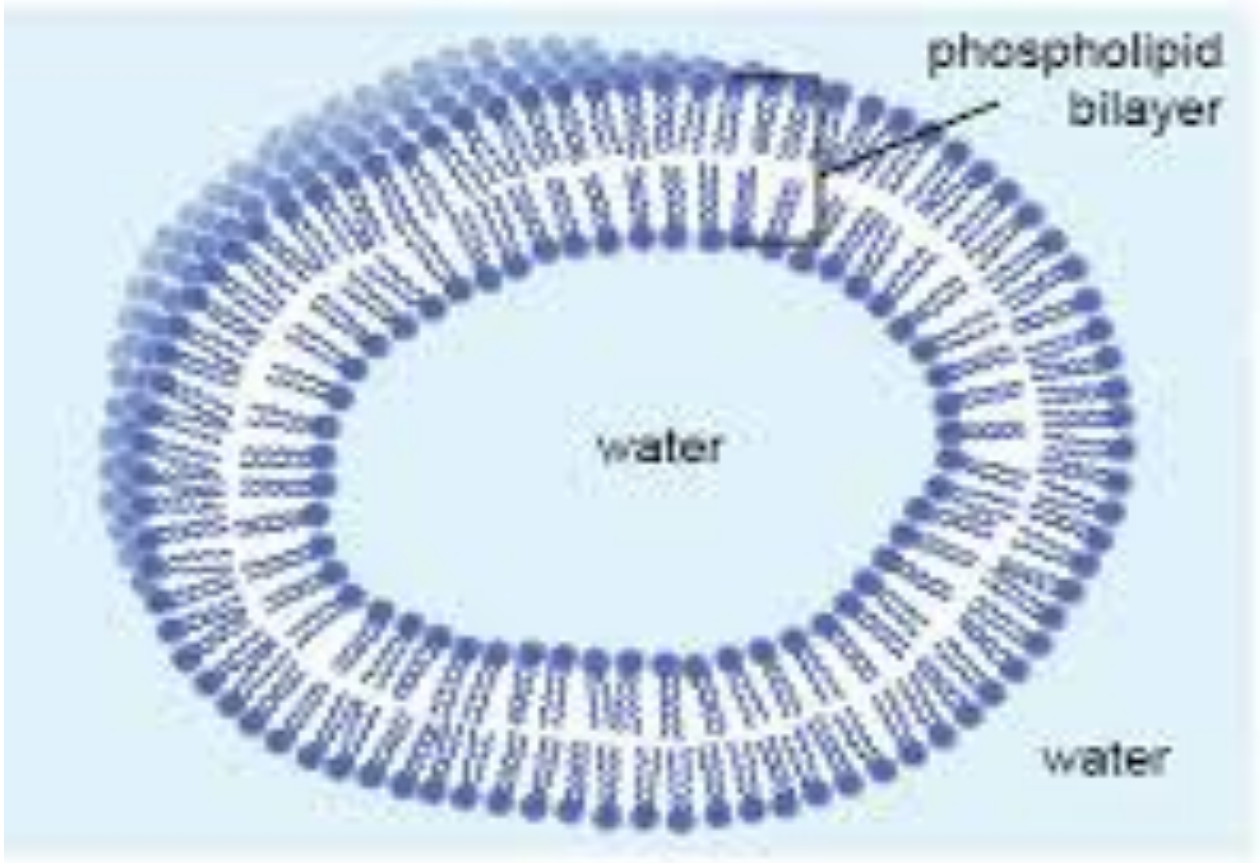
Low fluidity
Low permeability

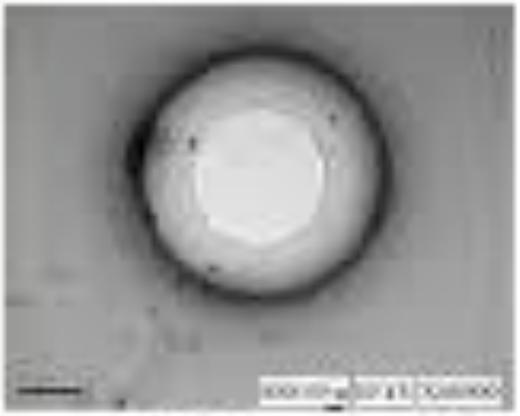
Lipid bilayer with many unsaturated fatty acids



High fluidity
High permeability

Cell membrane.





TEM image of a liposome at 60,000x magnification

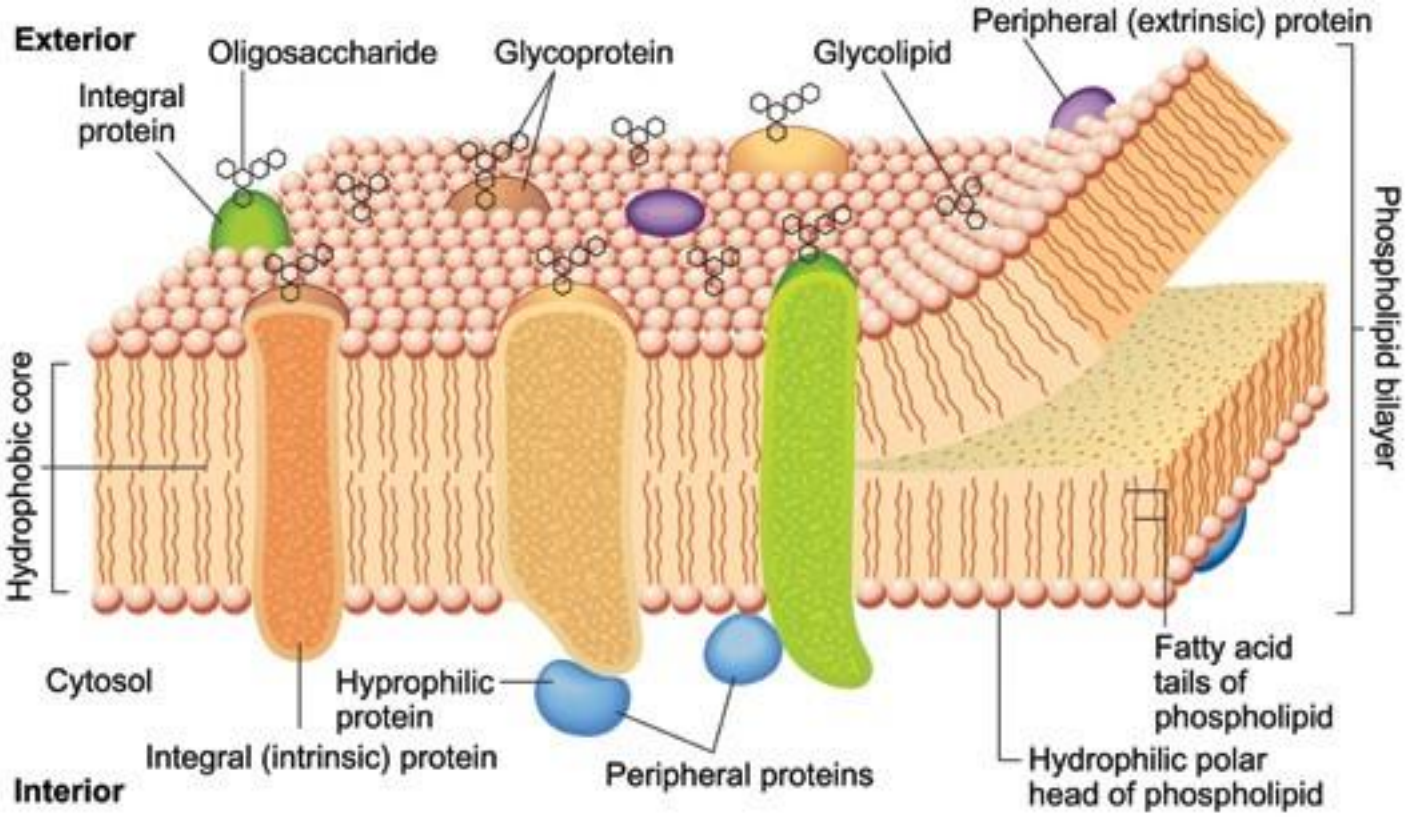
Role of cholesterol in cell membrane.

- Cholesterol is dispersed through out cell membrane, in the irregular spaces between the hydrophobic tails of the membrane lipids. It gives the membrane stiff and gives it strength.
- Cholesterol content of the membrane alters the fluidity of membrane.
- Regulate the activity of certain integral membrane protein.
- Decreases the permeability of membrane

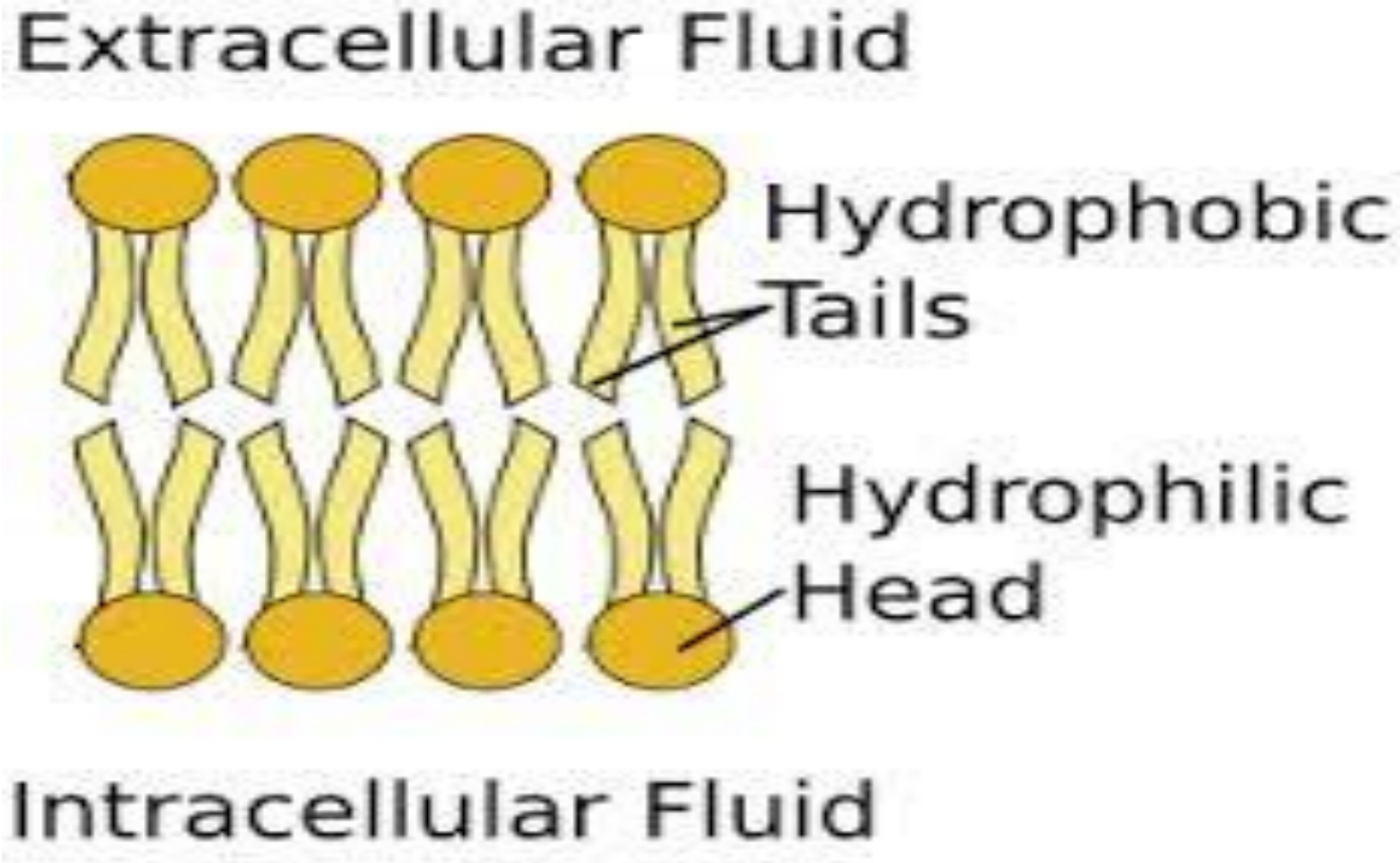
Role of cholesterol in cell membrane.

- When cholesterol is high the membrane become less fluid on the outer surface but more fluid in the hydrophobic core.
- The effect of cholesterol on membrane fluidity is different at different temperatures. At temp below the Tm cholesterol increases fluidity and there by permeability of membrane. At temp above the Tm cholesterol decreases fluidity.
- Cholesterol also increases flexibility and stability of membrane. Without it membrane break up.

Most protein molecule float about in the phospholipid bilayer forming a fluid mosaic pattern



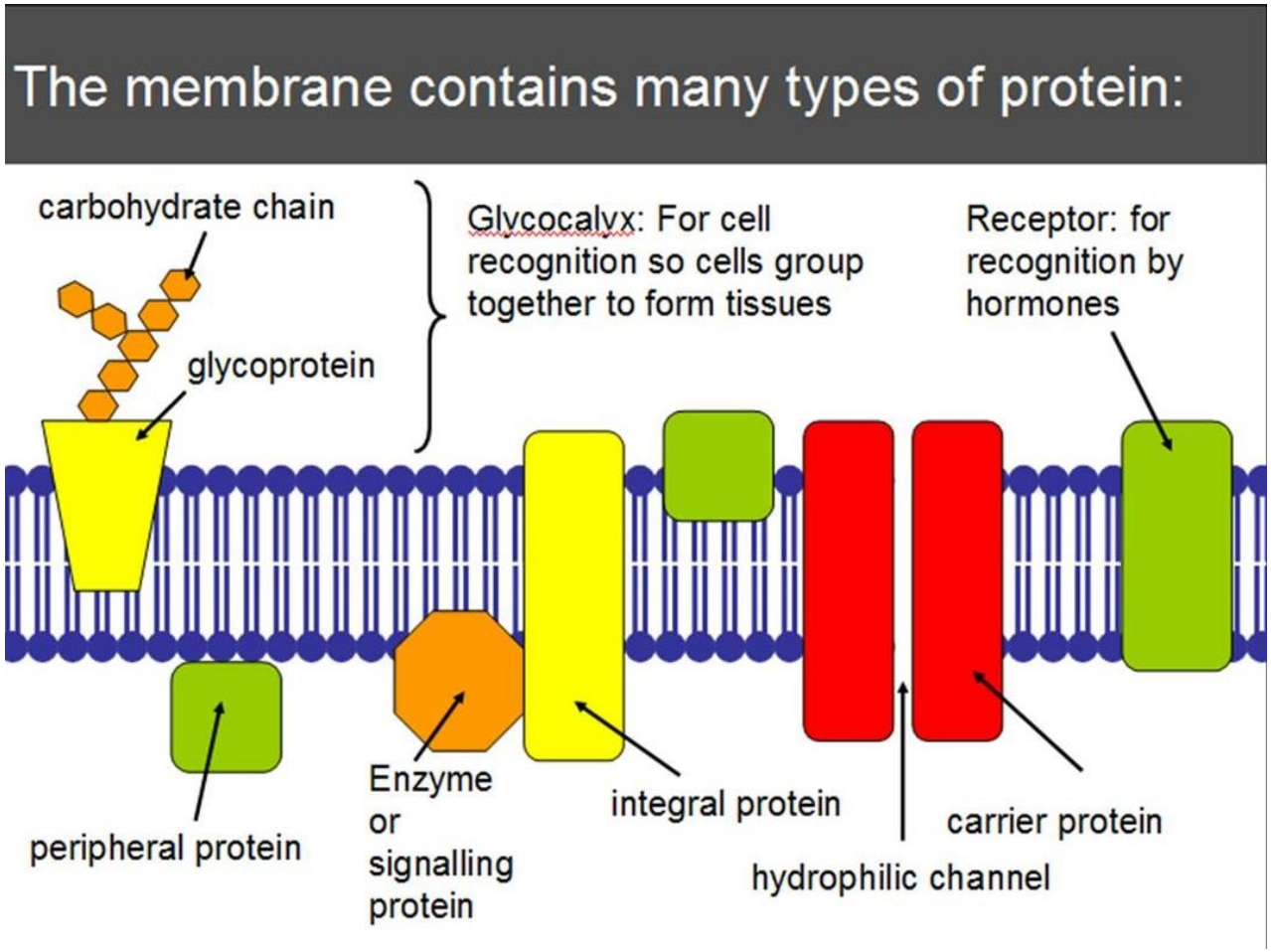
The possession of both hydrophilic and hydrophobic properties make the lipid an amphipathic molecule



Proteins

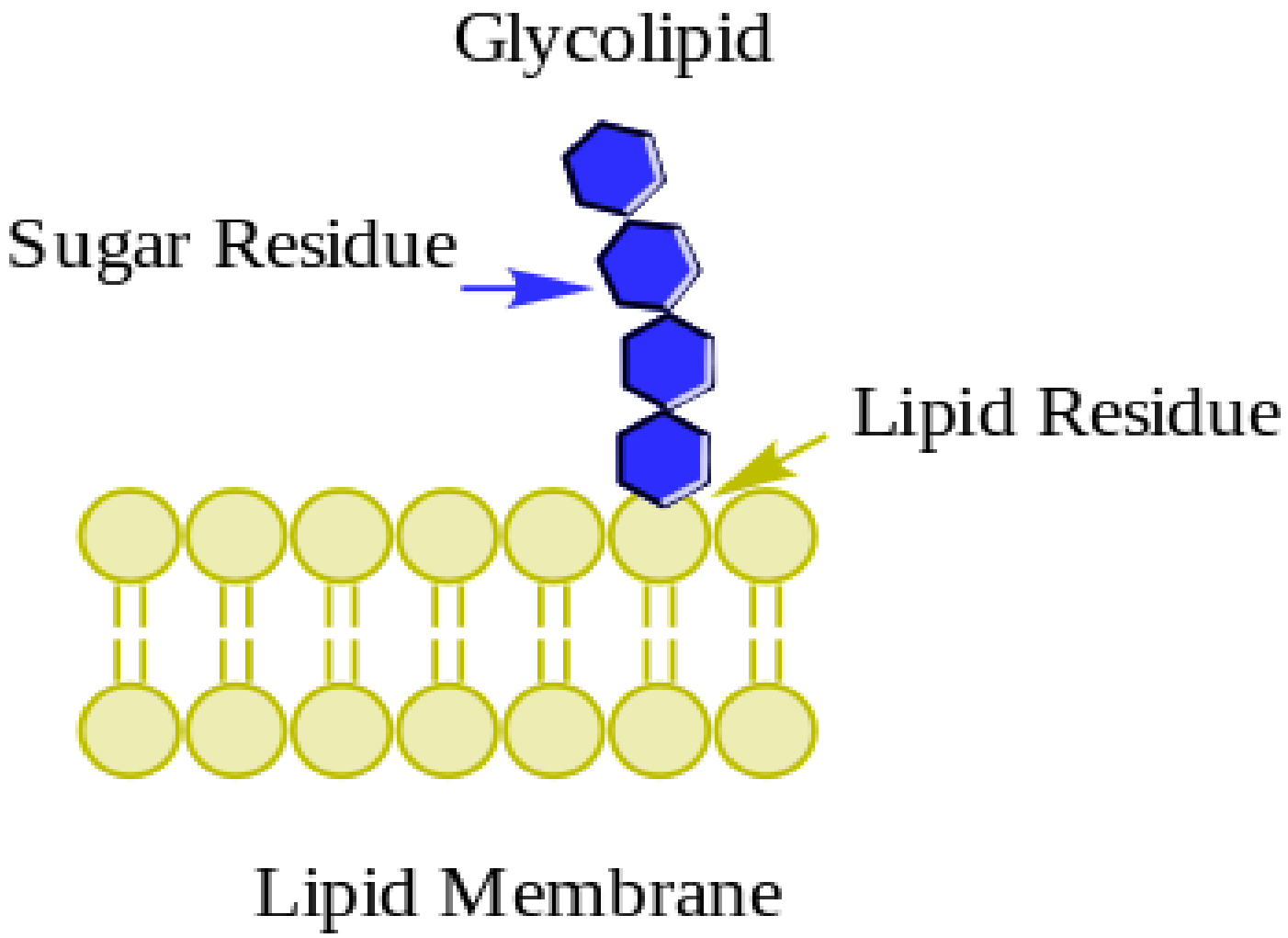
- The amount of protein varies significantly with the function of the membrane but makes up on average 50% of the mass of the membrane. Two types of proteins in cell membrane.
- **Peripheral proteins** that are attached to inside or outside of lipid bilayer.
- **Integral proteins** that cross the whole thickness of lipid bilayer.
- **Functionally--** these proteins are divided into various groups they form cell adhesion molecules that join cell together.
- Pump ions across the cell membrane
- Carriers that carry substances across the cell membrane.
- Ion channels through which ions move.
- Receptors for chemicals, hormones and drugs.
- Enzymes that catalyze chemical reactions.
- Other protein are lipidated ,that is they have specific lipids attached to them.

Most protein molecule float about in the phospholipid bilayer forming a fluid mosaic pattern

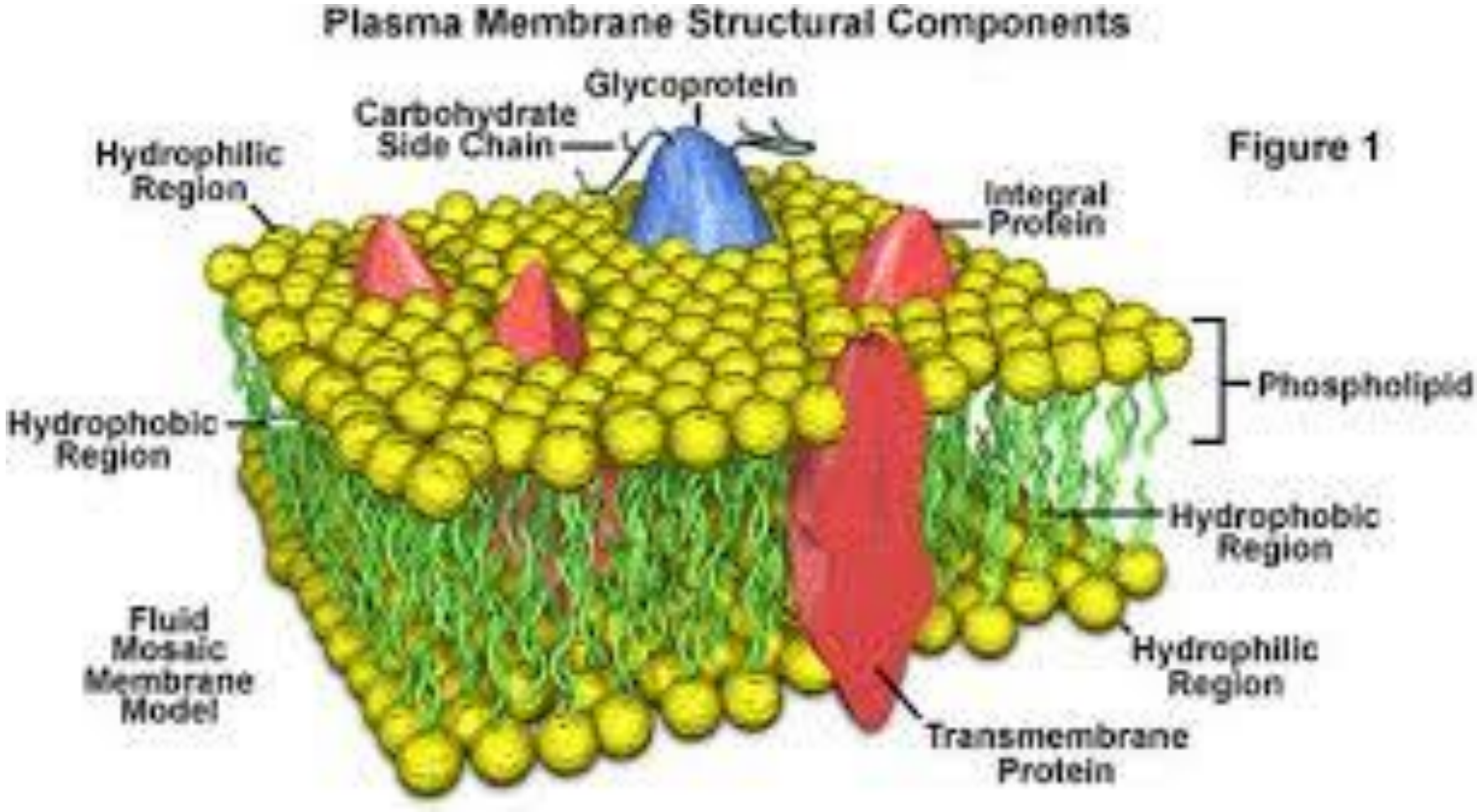


Carbohydrates(glycocalyx)

- On external surface of cell membrane ,membrane proteins and lipids are conjugated with short chains of polysaccharides.The carbohydrates are present as Glycoproteins or Glycolipids.
- This layer formed is called Glycocalyx and is involved in cell recognition phenomenon,formation of intracellular adhesions,adsorption of molecules to the surface.

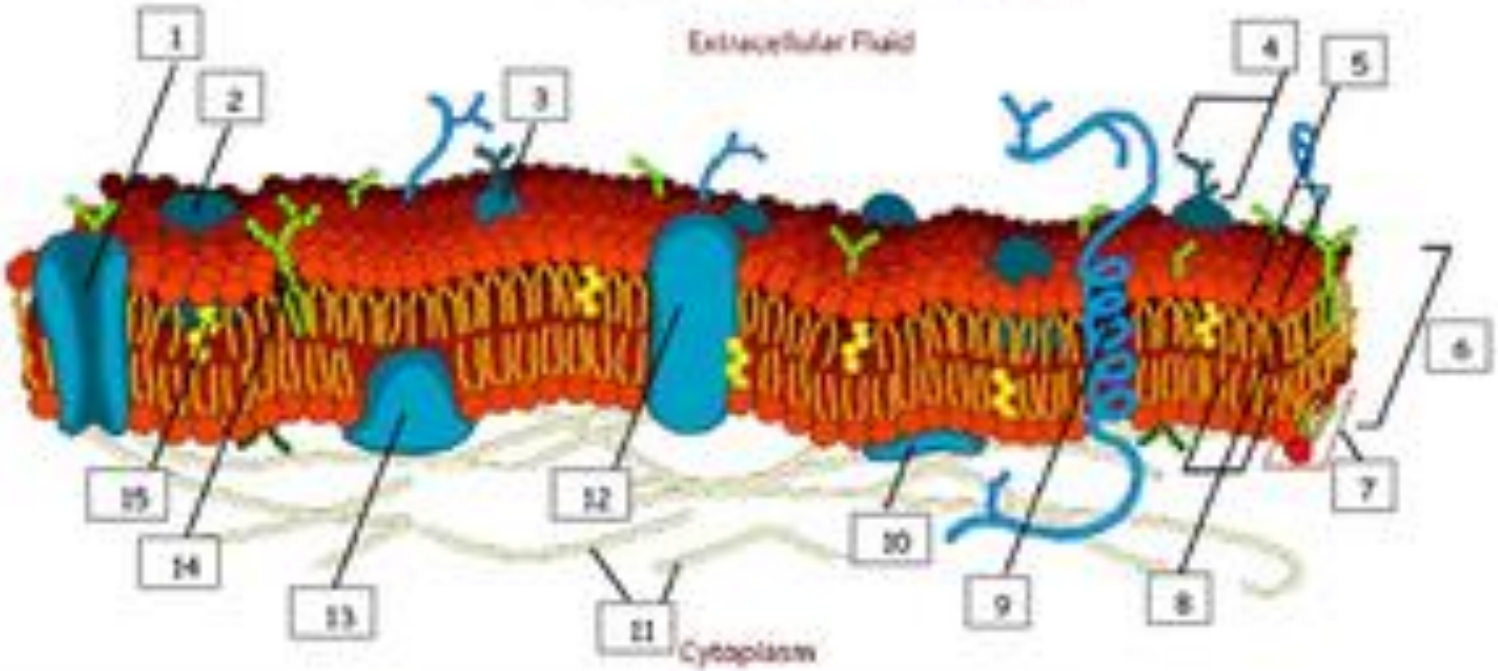

Glycolipid
Sugar Residue
Lipid Residue
Lipid Membrane

Most protein molecule float about in the phospholipid bilayer forming a fluid mosaic pattern



- A mosaic is a work of art made of individual tiles or other pieces assembled to form a picture or design

PARTS OF A CELL MEMBRANE



1) _____ 6) _____ 11) _____

2) _____ 7) _____ 12) _____

3) _____ 8) _____ 13) _____

4) _____ 9) _____ 14) _____

5) _____ 10) _____ 15) _____

Answer Key

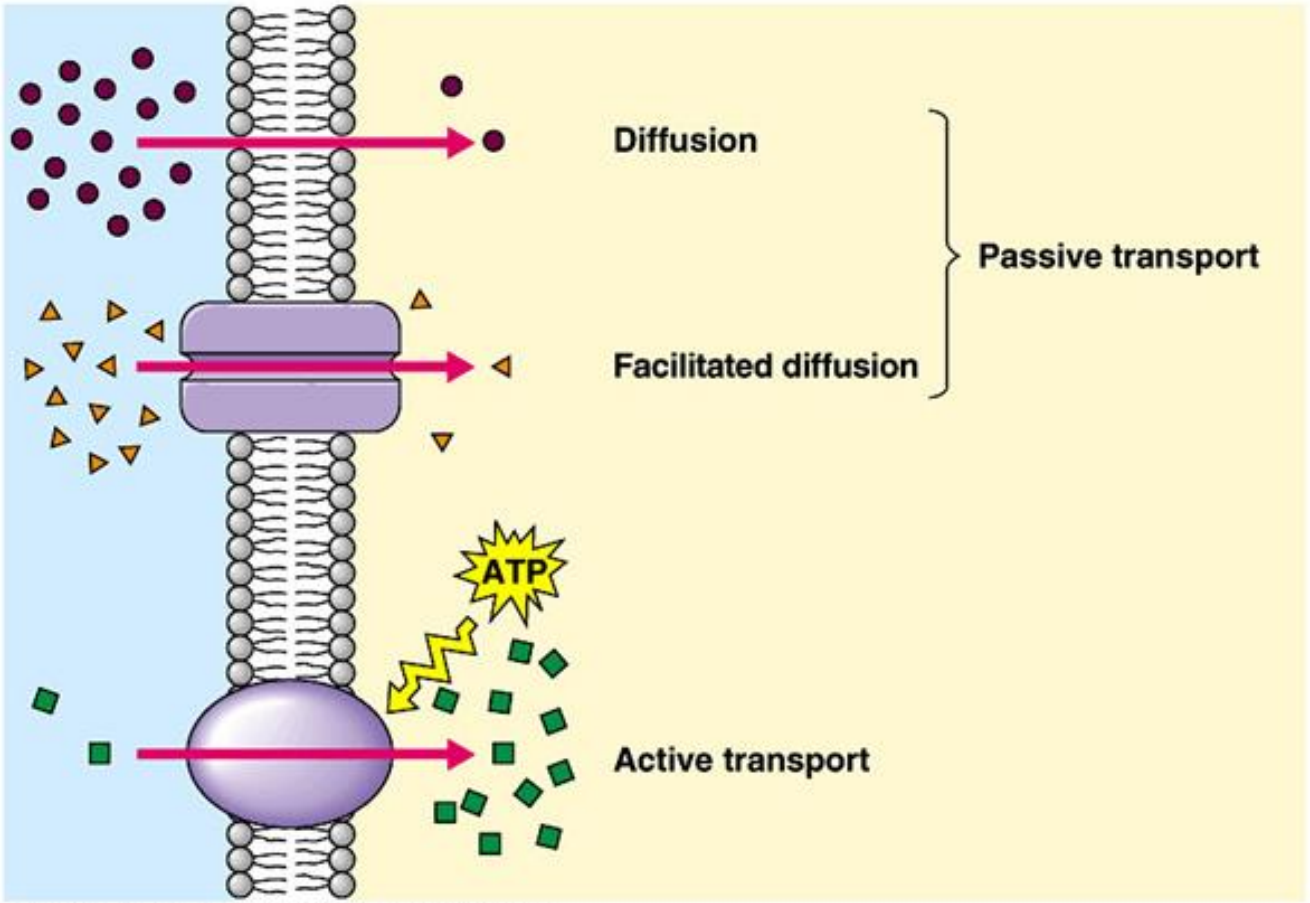
1) CHANNEL PROTEIN
2) GLOBULAR PROTEIN
3) GLYCOPROTEIN
4) CARBOHYDRATE
5) HYDROPHILIC HEADS
6) PHOSPHOLIPID BILAYER
7) PHOSPHOLIPID MOLECULE
8) HYDROPHOBIC TAILS
9) ALPHA-HELIX PROTEIN
10) SURFACE PROTEIN
11) CYTOSKELETON FILAMENTS
12) INTEGRAL PROTEIN
13) PERIPHERIAL PROTEIN
14) GLYCOLIPID
15) CHOLESTEROL

Transport across membrane.

How Molecules Cross the Membrane

	Active/ Passive	Molecules that Move	Direction	Energy Needed?	Protein Needed?
Diffusion	Passive	small, hydrophobic	down gradient (toward low conc.)	no	no
Osmosis	Passive	water	toward high conc. of solutes	no	no
Facilitated Diffusion	Passive	any (specific transporter)	down gradient (toward low cons.)	no	yes
Active Transport	Active	any (specific transporter)	specific: in or out, dep. on transporter	yes	yes

Transport across membrane.



Transport across membrane.

- The factors affecting the rate at which molecules cross cell membrane by diffusion are summarised in Ficks law.This states that the rate is proportional to

Surface area of membrane multiply difference in concentration across the membrane divided by thickness of membrane.